The burst of the real estate bubble as a promoter of gentrification in Tokyo and Osaka, 1980–2017

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Abstract

Our study shows that land price fluctuations are an important factor affecting suburbanization and gentrification of large cities. During a period of economic ascent, the rise of property prices favors commercial and office land use in central city areas, increasing their daytime population while decreasing the residential population. This shift stems from the fact that, in response to the rising land prices, developers tend to raise the height of buildings, and the land price elasticity of building height is smaller for residential than for commercial buildings. In a downturn period, however, with the decline of land prices and shrinking demand for commercial space, it becomes profitable to shift land from commercial to residential use in central locations; gentrification occurs as an unintended consequence of this shift. We provide support for our hypotheses, by examining the population dynamics in Japan's largest metropolitan areas before and after a nationwide real estate bubble and its burst.

Keywords: gentrification; real estate bubble; housing development; Japan

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1 Introduction

The share of the central city population in the major metropolitan areas (MAs) of the United States has fallen significantly in the second half of the 20th century (Brueckner and Rosenthal, 2009; Boustan and Shertzer, 2013; Baum-Snow and Hartley, 2019). This has been attributed to the increases in car use and highway construction (LeRoy and Sonstelie, 1983; Baum-Snow, 2007; Garcia-López, 2010), housing cycles due to housing capital depreciation and filtering down (Smith, 1979; Glaeser and Gyourko, 2005; Rosenthal, 2008; Brueckner and Rosenthal, 2009), residential segregation (Boustan and Margo, 2013), issues in coordinating redevelopment (Rosenthal and Ross, 2015; Brooks and Lutz, 2016; Owens III et al., 2017), and so on.

After 2000, however, the population, as well as the relative income and the proportion of college graduates, were found to grow again in the most central neighborhoods of US MAs (Couture and Handbury, 2017; Baum-Snow and Hartley, 2019) and in select European cities like London and Barcelona (Hamnett, 2003; González-Pampillón et al., 2019). The observed gentrification is argued to be associated with the neighborhood housing cycles (Brueckner and Rosenthal, 2009; Guerrieri et al., 2013), a desire to save commuting time and enjoy the non-tradable cultural and social amenities in the central city (Hamnett, 2003; McKinnish et al., 2010; Lee and Lin, 2013; Couture and Handbury, 2017), or the increasing value highly-skilled workers place on time (Su, 2019). In addition, Lehrer and Wieditz (2009) and Boustan et al. (2019) suggest that a massive investment in housing in the form of high-rise condominium towers has contributed to the gentrification of a city.

The present study provides empirical evidence that price fluctuations in the real estate market behave as an additional determinant of decentralization or recentralization of central cities, which has not yet been investigated in the literature.[1] Specifically, we focus on the two largest MAs in Japan: Tokyo and Osaka. Starting from the early 1980s and collapsing in the early 1990s, the real estate bubble that Japan experienced was one of the most aggressive ones in the history of its urban development. Intense property price fluctuations provide us with an opportunity to observe their impacts on central city population dynamics. Moreover, as the violent price fluctuations in the real estate market mainly occurred in a short time period (less than one decade), the demographic patterns and infrastructure construction that may affect central city population dynamics remained practically unchanged. This allows us to clearly identify the causal effects of land price fluctuations on central city gentrification.

We find that central cities' residential population shrank while their daytime population expanded in the price-surging period. After the burst of the real estate bubble, however, central locations' residential population grew significantly whereas their daytime population declined. Consistent with the population dynamics, commercial buildings dominated land use in the central locations during the bubble period but in the downturn period, the scale of "built-to-sell" housing construction (mainly in the form of high-rise condominiums) expanded. Guided by a body of stylized facts and empirical evidence, we attribute these patterns to the residential-commercial segregation in the central locations, first introduced by Ahlfeldt and McMillen (2018).

Using historical building height and land price data on Chicago, Ahlfeldt and McMillen (2018) find that the land price elasticity of building height is smaller for residential than for commercial

[1] In addition to the literature mentioned above, some studies (e.g., Cuberes et al., 2019) comprehensively examined the determinants of household location choice in a city.

buildings because the elasticity of substitution between land and capital is smaller.[2] Moreover, the building height elasticity of construction cost is larger for residential buildings.[3] In other words, in the locations where land prices are high, it is more reasonable to increase the building height of offices than that of homes. Their results explained the strong tendency for commercial activities to be concentrated in central business districts (CBDs) from the supply side, in addition to the traditional demand-side factors such as agglomeration economies (Fujita and Ogawa, 1982; Lucas and Rossi-Hansberg, 2002).

Our findings complement Ahlfeldt and McMillen's (2018) conclusions: we find that the residential and commercial segregation caused by the aforementioned supply-side factor, combined with the intense fluctuations in land prices, can change urban spatial structure (i.e., cause decentralization or gentrification). During an economic upswing, central locations are likely to be dominated by the commercial use of buildings, to fully exploit the value of "space in the sky," partially crowding out the residents who lived there. According to our data, commercial land prices in Tokyo and Osaka rose much faster than those of residential land during the period of the bubble economy, which is compatible with the increase in the daytime (employment) population and decrease in the nighttime (residential) population in the central locations.

However, during the economic downturn, we found that commercial land prices quickly fell back to their pre-bubble levels, but residential land still maintained a significant price increase compared to its 1980 price levels. In other words, the demand for commercial buildings fell more than that for homes, and so did their prices, which increased the relative comparative advantage of developing homes in central city areas. After the bubble burst, the nighttime population rebounded in central locations, accompanied by a decline in the daytime population. We show that the observed pattern of intra-MA population growth was not affected by changes in confounding factors, since these factors were largely stable across the study period. Moreover, we find that high-rise condominium towers were the major housing type adopted by newcomers to central locations. As a result, there was a significant unit price premium on the large-sized land (relative to the average residential land price) that allowed the high-rise condominium development in the central locations.[4]

The present study contributes to the literature by explaining the origin of gentrification from a new perspective, adding to Brueckner and Rosenthal (2009), Couture and Handbury (2017), Baum-Snow and Hartley (2019) and so on. In particular, existing relevant studies mainly focus on the gentrification in the United States and European countries, with little research has been done on Asian cities. However, cities in the West are significantly different with that in Asia, as the latter tend to be larger, denser, more monocentric, and differently organized in terms of land use.[5] Our

[2] Ahlfeldt and McMillen (2018) argue that, since unit construction costs increase with building height, there exists a correspondence between land price and building height. As the land price increases, land developers tend to make the buildings higher. However, it is more difficult to compensate residents than office users for the limited access to private and communal exterior space, making high-rise buildings more preferable for office uses than for residents. In addition, Liu et al. (2018) find that high-productivity companies are located higher up in high-rise office buildings, with less productive offices found further down. Companies' preference for a view further promotes the construction of high-rise buildings.

[3] The cost of height is higher for residential than for commercial buildings due to some notable differences in the design of commercial and residential buildings. As a result, the losses of usable floor space as building height increases are different. For more details, see Ahlfeldt and McMillen (2018).

[4] Small-sized vacant land (for example, 200 m^2 or smaller) does not allow for high-rise condominium development.

[5] Major Asian cities tend to be different from their counterparts in North America and Europe in terms of spatial structure. For example, mega-cities are more likely to emerge in Asia. According to the United Nations (2019), there were 33 mega-cities in the world in 2018, of which 19 are in Asia, only two of them are in North America and three of them are in Europe. Moreover, as stated

study partially fills this gap by focusing on the gentrification in two typical Asian MAs. Our analyses are also connected with the geography literature. A seminal work by Smith (1979) indicated that gentrification might be fundamentally guided by capital, but not people; our results partially validate this standpoint.

The remainder of this paper is organized as follows. Section 2 presents the background information on the Japanese real estate market. Section 3 details the hypotheses, stylized facts, and empirical results. Section 4 introduces some descriptive and quantitative evidence regarding the mechanism of gentrification. Section 5 concludes.

2 *Japanese real estate market, 1980–2017*

The real estate bubble began to expand rapidly from the late 1980s in Japan. Regardless of the approach used to calculate the price index, average land prices in Japan doubled in the period between 1985 and 1990, with prices rising much more in the larger cities. Then, the real estate bubble fully collapsed after 1990 (for more details on the Japanese real estate bubble, see, e.g., Kanemoto (1997), Nakamura and Saita (2007), and Zhang (2017)). The causes of the bubble and its burst have been carefully studied in various strands of literature and have been attributed to the over-relaxed macroeconomic policy, external economic shocks (e.g., the Yen appreciation following the 1985 Plaza Accord), and so on. By 2017, the average land price in Japan had not yet recovered to its early-1990s peak when the bubble burst.

The commercial and residential land markets have exhibited different price fluctuations during and after the bubble. Figure 1 shows the land prices by commercial and residential use for the six largest Japanese cities and the price data for the Tokyo Prefecture in 1980–2017.[6] In both plots, the price increase of commercial land is much more significant than that of residential land, that is, capital gains are larger for the former during the bubble period (1980–1990). In addition, office space rents are generally higher than residential housing rents in Japanese urban centers (Shimizu et al., 2010). Therefore, office buildings and commercial facilities were intensively constructed in Tokyo during the bubble period and small houses and land were aggressively bundled for office building construction under the strong expectations of higher office rents accompanying the expanding bubble in the late 1980s (Shimizu et al., 2010). However, after the burst of the bubble (after 1990), commercial land experienced more significant capital losses; in 2001, its price fell back to the 1980 level (left panel of Figure 1), whereas residential land still maintained a capital return of 47% (taking the 1980 price as a benchmark).[7] In other words, after 1990, the residential land price increased relative to the commercial land price (the green lines in Figure 1).

[Figures 1–2 about here]

by Brueckner et al. (1999) and Tabuchi (2019), residential locations in the major US MAs, Paris, and Tokyo are systematically different: the rich and poor colocate in the central locations of Tokyo whereas the poor (rich) are concentrated in the central locations of US MAs (Paris).

[6] The land price index for the six largest cities is a widely used indicator reflecting Japanese real estate prices. The six largest cities are Tokyo, Yokohama, Osaka, Kyoto, Kobe, and Nagoya, of which five are included in our sample area (except Nagoya), as described in Section 3.

[7] City level land price indices are not readily available, but we show the related data for the city of Tokyo in Figure A1, estimated by Shimizu and Nishimura (2007) using land transaction data. Land price volatility in Tokyo is more intense than the average for the six major cities, but the basic pattern is similar: a relatively higher return (less loss) on capital for commercial (residential) land during the bubble period (after the bubble burst).

The surging land prices during the bubble period partially restrained land transactions because landlords expected that their assets in hand would be appreciating further. In addition, housing affordability deteriorated, discouraging home purchases. As shown in Figure 2, the number of land transactions decreased in the bubble period in both the city of Tokyo and the Tokyo MA, as well as in the entire nation. After the bubble burst in the early 1990s, however, the number of land transactions in Tokyo city and the Tokyo MA increased, although it continued to decrease nationwide (data for Osaka are not available). Consistently with the trends of land transactions, we find that the number of house tenure changes also decreased in the bubble period due to the increasing costs of owning a home. The number of moves from rental housing to owned homes dropped sharply in the bubble period, with the pattern being further magnified in major cities. During 1979–1983 (i.e., before the bubble), 2,050,000 households moved from rental housing to owned homes nationwide (185, 000 for the city of Tokyo). The subsequent jump in housing prices reduced the number of first-time home-buyers; as a result, this figure dropped to 1,736,000 and 1,659,000 during 1984–1988 and 1989–1993, respectively (147,000 and 107,000 for the city of Tokyo). After the downturn of property prices, the number of first-time home-buyers rebounded to 2,124,000 during 1994–1998 (198,000 for the city of Tokyo; Hirayama, 2005, 2006). Central cities witnessed a housing boom after the bubble burst (right panel of Figure 2), as will be formally discussed later.

The reasons for the rebound in housing development in central cities are manifold; the following are particularly relevant: First, declining land prices after the bubble burst improved housing affordability and, in turn, promoted new housing development. Second, a low interest rate and the macroeconomic policy to accelerate home purchases, to ease the economic recession, expanded the demand for new residential buildings (Hirayama, 2005).[8] Third, due to the strict legal regulation, Japanese residential rents have been mainly stable (compared to the office space rents), even in the bubble period; this implies that the declining housing prices have substantially improved the rent-price ratio, or capitalization rate (Shimizu et al., 2009).

Another reason for the increase in housing development in central cities is the saturation of the office supply there. Due to the collapse of the bubble economy, vacancy rates soared in many office buildings; the changes in economic conditions prompted landlords to alter their operations by dedicating commercial land to housing development (Shimizu et al., 2010). Moreover, many Japanese companies were struggling with debt after the burst of the bubble economy, and, therefore, had to sell property such as land; this land, previously used as parking lots or offices, was converted into high-rise condominiums (Hideo, 2014).

3 Hypotheses and baseline results

3.1 Hypotheses and stylized facts

According to Ahlfeldt and McMillen (2018), as summarized in the first section, the construction of tall buildings in central locations is profitable even if construction costs are high because the land is even more expensive and the rent would be high. Regarding the trend in land use, in areas with

[8] After the bubble burst, the Japanese government promoted housing construction by increasing the provision of loans by the Government Housing Loan Corporation. Moreover, the tax reduction for households purchasing homes was also increased greatly in 1999 (Hirayama, 2005).

high land prices, office and commercial buildings will be preferred to residential buildings. We thus expect that: *Segregation of office/commercial buildings and homes in the central cities would be strengthened during the bubble period. However, land prices declined and demand for commercial and office space shrank after the burst of the bubble economy, this was a signal for land developers to shift from commercial land use to residential land use.*

Since Japan experienced intense land price fluctuations during the real estate bubble, we are able to test these hypotheses by examining the land use trend and population dynamics in central cities before and after the bubble economy. Note that, although Japanese urban planning constraints may prevent housing lands from being used for other purposes, no legal regulations exist that prohibit the conversion of commercial land into housing. Therefore, land use conversion is legally feasible in the central locations of the Tokyo/Osaka MA.[9]

Regarding sample selection, we are particularly interested in the population dynamics in the large cities because they tend to experience significant land market price fluctuations and the land supply there tends to be tighter and more sensitive to price changes. We focus on the two largest Japanese MAs: Tokyo and Osaka, which include 9 out of the 47 prefectures of Japan (see Figure 3).[10] They include 44.6% of Japan's population (as of 2015), although the land area is only 8.9% of the total. The economic agglomeration in the central cities of these two MAs (i.e., the cities of Tokyo and Osaka) is even more extensive: they account for only 0.6% of the country's total land while accommodating 9.4% of the residential population and absorbing 11.0% of the daytime population in 2015. Moreover, these two MAs include all the 55 administrative units (at the municipality level) in the country with a residential density of more than 10,000 persons per km^2. Therefore, by studying these two MAs, we are able to systematically evaluate the gentrification process, if any, in Japan's densely populated urban areas.

[Figures 3–4 about here]

Both MAs are highly polarized, with the densest municipalities being located closer to central Tokyo/Osaka (see Figure A2). To measure the inter-MA population dynamics, we further define a four-level hierarchy for the Tokyo MA. The first level is the entire Tokyo MA (34.0 million residents in 2005), the second is the city of Tokyo (8.3 million), and the third (the fourth) is the central eight (central three) municipality level wards of Tokyo city, with a residential population of 1.6 million (0.3 million) (see the locations in Figure 4a). The central eight wards are usually defined as the CBD of Tokyo, especially the three central ones (Chiyoda, Chuo, and Minato). As will be formally discussed later, the more central locations are the ones that tend to exhibit a higher density in both daytime and nighttime populations and accommodate a larger number of high-rise buildings.[11] For the Osaka MA, we define the hierarchy levels in a similar manner, with the first level being the entire MA (19.3 million residents in 2005), the second being the city of Osaka (2.5 million), and the third being the central three wards of Osaka city (0.2 million) (Figure 4b). Note that

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[9] Shimizu et al. (2010) systematically estimated the probability of land use conversion from office space to housing using micro data of the housing and land market in Tokyo.

[10] The Tokyo MA includes four prefectures (Tokyo, Kanagawa, Chiba, and Saitama); the Tokyo Prefecture comprises the city of Tokyo and the other affiliated municipality level cities/towns; the city of Tokyo consists of a bundle of municipality level wards (see Figures 3 and 4). This is similar to the Osaka MA.

[11] In line with the traditional core-periphery type of urban spatial structure, central locations in the Tokyo/Osaka MAs are characterized by a significant land price premium. Moreover, of the buildings with 30 stories and above in Tokyo Prefecture, 38% (81%) and 50% (78%) were located in the central three (eight) wards of Tokyo city in 1990 and in 2010, respectively (Data sources: Tokyo Statistical Yearbook).

Osaka city is much smaller in land area and population size than Tokyo city; its CBD is, therefore, relatively condensed.

We then turn to examine the land use trends in the central locations of the sample area. Since data (at the municipality level) indicating the purpose of various types of buildings (residential, commercial, etc.) are not available and many of the buildings exhibit a combination of residential and commercial use, we use daytime population density as a proxy for the degree of commercial land use in an area and nighttime (residential) population density as a proxy for the degree of residential land use in that area. If land use in central cities is segregated and increasingly dominated by commercial use, we expect that the nighttime population will shrink whereas the daytime population will increase.

[Figures 5–6 about here]

Figure 5 shows the nighttime population growth of each hierarchy during 1980–2017. Although the two MAs, as a whole, exhibit solid growth in the entire study period, their central locations were declining significantly during the bubble period. The population size of the central locations in Tokyo and Osaka rebounded slightly in the late 1990s, although the trend of population recovery did not materialize until 2000; since then, the annual growth rate has exceeded 2.0% for the central three wards of both Tokyo and Osaka.[12]

Figure 6 (left panel), which displays the daytime population in central cities, further validates our hypothesis. The daytime population grew differently with (or, was inversely proportional to) the nighttime population, which grew in central locations during 1980–1990 but decreased after the bubble burst. The more central locations tend to show a stronger growth during the bubble period. For example, the central three wards of Tokyo (Osaka) reached an extremely high daytime population density (63,000 (51,000) persons per km^2) in 1990. Then, the central three wards of Tokyo (Osaka) lost 14% (16%) of their daytime population in the two decades following the bubble burst (1990–2010). As a result, the ratio of the nighttime population to the daytime population first declined during 1980–1990 and then rebounded after 1995 (Figure 6, right panel), implying that the residential and commercial land use segregation in the central cities, proxied by the nighttime-to-daytime population ratio, emerged in the bubble period and weakened after the bubble burst.

3.2 Baseline results

Based on the stylized facts above, we may infer that the burst of the real estate bubble was a potential promoter of gentrification in Tokyo and Osaka after the bubble burst, if we are able to confirm that these causal effects hold after controlling for the confounding factors. Note that the macroeconomic factors that caused the real estate bubble and its subsequent burst clearly do not stem from the gentrification process of Japanese cities and that the economic bubble also affected other sectors, such as the stock market. Therefore, the exogeneity assumption is satisfied when analyzing the impacts of the burst of the real estate bubble on gentrification. We first formally validate the association between nighttime-to-daytime population ratio and population growth after 1990 using

[12] The Residential Population Survey of Japan (various years) reports the ward level average income of residents for the city of Tokyo, showing that the taxable income of the residents of the central three wards was 1.37 times that of the city average during 1990–1995; this figure increased to 1.61 in 2005 and to 1.69 in 2015. For the central eight wards, it increased from 1.11 during 1990–1995 to 1.21 in 2015. This pattern is consistent with the gentrification trend, as observed in previous studies: the central locations became increasingly attractive for wealthy residents.

disaggregated data at the municipality level. Municipality level daytime population data are only available for the Tokyo/Osaka Prefecture (for other prefectures that are not the core of a large MA, daytime population and nighttime population are less disparate and, therefore, not reported in the relevant Prefectural Statistical Yearbook). Such data are also only available for urban areas (municipality level wards and cities, but not towns and villages). Therefore, our regressions are mainly based on the 49 (56) urban municipalities of the Tokyo (Osaka) Prefecture. Note that the nighttime-to-daytime population ratio in our sample ranges between 0.038 and 1.531 in 1990 (Table A1), implying sufficient variation in the key explanatory variable. In other words, some municipalities in our sample are highly dominated by commercial land use, with a daytime population more than 26 times its residential population, whereas for some peripheral areas in the Tokyo/Osaka Prefecture, the residential population is much larger than the daytime population. This trend is consistent with the stylized facts about the commercial-residential land use segregation in the Tokyo/Osaka MA.

In Table 1, we first present a naïve OLS regression result, with residential population growth during 1990–2015 as the dependent variable, and nighttime-to-daytime population ratio in 1990 as the independent variable. Land in municipalities with a lower nighttime-to-daytime population ratio in 1990 tend to be more dominated by commercial use and to experience a more pronounced decline in land prices after the bubble burst (according to Figure 1).[13] Therefore, these municipalities may experience more land use conversions from commercial to residential and can relatively absorb a larger residential population, as we hypothesized. This is confirmed by the municipality level regression results. The relevant estimated coefficient is negative and statistically significant, as seen in column 1 (panel A) for the Tokyo Prefecture and column 1 (panel B) for the Osaka Prefecture.

[Table 1 about here]

We then address the issues of the confounding factors. Since municipalities with a low nighttime-to-daytime population ratio tend to be closer to the CBD (Figure 6), they have a higher initial residential density (Figure A2). This inherent heterogeneity may be associated with the differential population growth pattern after the bubble burst, and this association may be related to some unobservable factors (e.g., amenities) rather than the land use pattern. In columns 2 and 3 of Table 1, by replacing the independent variable with the geographic distance to Tokyo/Osaka Station (a proxy for proximity to the CBD) and the population density in 1990, respectively, we do find that both factors are significantly correlated with the post-1990 population growth in the Tokyo Prefecture (results are insignificant for Osaka, see panel B). However, the R-squared is much smaller in columns 2 and 3 than that in column 1 (0.081 and 0.056 vs. 0.325 for Tokyo; 0.004 and 0.018 vs. 0.421 for Osaka), partially implying that the nighttime-to-daytime population ratio is more persuasive, as a determinant of the post-1990 population growth, than the other two factors. After adding these two variables into the baseline regression model, the nighttime-to-daytime population ratio in 1990 is still significantly correlated with the population growth in 1990–2015 (column 4 of Table 1).

[13] In municipalities where land is mainly dominated by the existence of factories, the residential population would also be much smaller than the daytime population (people at their workplace). In such cases, the low nighttime-to-daytime population ratio is not related to a high dominance of commercial land use, causing a measurement problem. However, within our sample, all the municipalities with a low nighttime-to-daytime population ratio are in the central locations of the Tokyo/Osaka MA, where the number of factories is very limited.

This pattern is further validated by a subsample regression using only the municipality level wards in the city of Tokyo (23 wards) and the city of Osaka (24 wards); using this sub-sample, we are able to address the issue that some peripheral municipality level cities in the Tokyo/Osaka Prefecture is not the commuting zone of the city of Tokyo/Osaka, and their nighttime-to-daytime population shares and population growth are likely to be affected by some unobservable factors; results are essentially unchanged (column 5 of Table 1). We also test using the data from 1980 to 1990 in column 6, with the nighttime-to-daytime population ratio in 1980 as the independent variable; it is found to be positively correlated with the residential population growth in the bubble period. In other words, the residential population in the municipalities with a low nighttime-to-daytime population ratio was shrinking during the real estate bubble, which is consistent with the stylized facts, as shown in Figures 5 and 6.

4 Additional evidence and mechanism

In this section, we provide detailed information regarding the changes in the housing and land market before and after 1990, which further supports our hypothesis that the bubble burst behaved as a promoter of gentrification.

4.1 Intensive housing construction in central locations after the bubble burst

Accompanied by the gentrification of the Tokyo/Osaka MA, we may assume that there was intensive housing construction in our sample urban areas after the bubble.[14] Figure 7 shows the new housing construction in the Tokyo/Osaka MA, by separating the "built-to-sell" dwellings (condominiums or detached houses) and "built-to-rent" ones (single-bedroom apartments). Note that there are other types of housing construction such as owner-occupied homes built by the landlord and issues houses for employees built by the employer. However, these are limited; "built-to-sell" and "built-to-rent" dwellings account for more than 90% of the new housing construction in the sample central cities.[15] We find that the volume of new construction before and after the bubble is comparable in the entire Tokyo/Osaka MA. Although construction exhibited a sharp drop immediately after the burst of the bubble, it quickly recovered.

[Figures 7–8 about here]

However, once we focus on the cities of Tokyo and Osaka, especially the central three/eight wards of the cities, we find that they show a stronger trend of expanding housing construction after the bubble burst (relative to the bubble period), as housing became more affordable and a considerable amount of commercial land there was likely to be transformed into residential land. The proportion of new housing starts (in m^2) in the central three wards of Tokyo/Osaka in the entire Tokyo/Osaka MA was below 2% in the bubble period, but it quickly jumped to approximately 8% in the early 2000s (Figure 8). For example, annual new housing starts stabilized below 0.4 million m^2 in the central three wards of Tokyo during 1980–1994, however, this figured sored from 0.4 to 1.7

[14] The Japanese housing market is dominated by new homes, as existing homes are discriminated against in the mortgage market and they are less preferred by home buyers. For more details, see Kobayashi (2016) and Xu and Wang (2019).

[15] In our study, we mainly focus on the "built-to-sell" and the "built-to-rent" dwellings, because these two types of dwellings account for, on average, 81.5% of the Tokyo/Osaka MA's new dwelling supply in 1980–2017 (the more recent the year, the higher the proportion). For Tokyo city and Osaka city, this proportion has stabilized above 90%.

during 1995–2002 (Figure 7). This is consistent with the population inflow toward the central city areas. In fact, the proportion of Tokyo (Osaka) city's residential-use buildings in the total area of new buildings has been rising (i.e., the share of commercial-use buildings declined) since the collapse of the real estate bubble (Hirayama, 2005).

By looking at the types of new housing construction, we find that the share of "built-to-rent" buildings peaked during the bubble (at approximately 80% of Tokyo city's new housing construction) but quickly shrank after 1990 (below 40%) (Figure 7). Instead, "built-to-sell" dwellings started to dominate the housing construction after 1990. [Note that the two types of housing differ substantially. As shown in Figure A3, "built-to-sell" dwellings (70–90 m^2 on average) are larger relative to "built-to-rent" ones (40–60 m^2 on average). Both of these types are generally smaller than owner-occupied detached houses (120–140 m^2 on average).] During the bubble period, most housing developments were small-sized "built-to-rent" dwellings because large-sized homes were not affordable. After the bubble burst, with the declining land prices and improving housing affordability, central cities started intensive housing construction mostly of large-sized "built-to-sell" dwellings.

This trend in housing construction was, however, not widely spread across the country. By examining the changes in the share of "built-to-sell" dwelling units in the total of new housing units constructed, we find that only the prefectures in the Tokyo/Osaka MA exhibited the trend of shifting from "built-to-rent" toward "built-to-sell" dwellings (Figure A4); the ratio of the two types of dwellings remained stable in other prefectures. This implies that the trends in the Tokyo/Osaka MA were not caused by national changes in building standards, taxes, residents' preferences, and so on; otherwise, similar trends would also be expected to emerge in other prefectures.[16] Instead, the observed trend changes in the Tokyo/Osaka MA's housing development may have been affected by the extraordinary real estate price fluctuations there.

Note that, based on Figures 5 and 7, this population inflow occurred after, but not before, the housing construction boom. The housing boom in central cities started to intensify during 1993 and 1995 because commercial land prices had fallen to almost half of their peak by that time.[17] As we expected, this may have promoted the land use conversion in central cities; after 1995, the volume of annual new housing starts (particularly for the "built-to-sell" dwellings, denoted by the dashed lines in Figure 7) clearly exceeded that of the previous years. However, the residential population in the central locations only grew at a very low rate during 1995–2000, and the large population inflow did not occur until 2000. This provides some evidence against the argument that the housing boom in the central cities was simply the result of the population inflow.

4.2 Increase in the number of high-rise condominium towers in the central locations

Of the increasing number of "built-to-sell" dwellings in the central cities, we find that most are condominiums and not detached houses. Table 2 displays the changes in the housing stock of Tokyo/Osaka city. During 1998–2013 (data for the earlier years are not available), the total housing

[16] The Aichi and Hiroshima prefectures each include a major city (Nagoya city and Hiroshima city, respectively); they also experienced a significant real estate bubble, although to a much smaller extent than the Tokyo/Osaka MA. Therefore, they show a similar trend of shifting from "built-to-rent" to "built-to-sell" dwellings (Figure A4).

[17] As shown in Figure 1, commercial land prices dropped by 35% (44%) in 1993 for the six largest cities (for the Tokyo Prefecture), compared to their price peak in the bubble period; by 1995, the prices had declined by 60% (63%).

stock increased by 1,132,800 (240,500) units in Tokyo (Osaka) city, of which 845,400 (286,500) were condominiums (and a very limited number of single-room apartments in buildings with six or more stories).[18] Construction of new low-story condominiums or detached houses is limited. In 2013, dwelling units in buildings with six or more stories accounted for 34% (51%) of Tokyo (Osaka)'s total housing stock, whereas this percentage was only 21% (36%) in 1998. Dwelling units in buildings with 15 or more stories exhibited the largest growth (177% and 130% for Tokyo and Osaka, respectively, in 2003–2013), implying the prevalence of high-rise condominium towers.

[Table 2 about here]

Table 3 displays the stock and locations of the Tokyo Prefecture's high-rise buildings (detailed data for the other prefectures are not available). The number of buildings with nine or more stories in the Tokyo Prefecture increased by 349% during 1980–2010, approximately half of these buildings are located in the central eight wards of Tokyo, although these wards account for only 6.2% of the prefecture's land area. For the new construction of buildings with 30 or more stories, 77% (97%) are located in the central eight wards (the city of Tokyo). This implies that the development of high-rise buildings was mainly concentrated in the central locations.

[Table 3 about here]

Moreover, as displayed in Table 4, we find that an increasing proportion of the super high-rise buildings (60 meters or higher) in the Tokyo Prefecture (data for the Osaka Prefecture are not public) are used for residential rather than for commercial purposes. For the super high-rise buildings constructed during the bubble period (some of them completed in 1990–1994, since super high-rise buildings take a few years to complete), only approximately 15% were exclusively for residential use, and approximately 60% were for commercial and office use (the rest exhibited a combination of commercial and residential uses). However, in the following decades, an increasing number of super high-rise buildings were constructed for residential use; those exclusively for residential use accounted for approximately 35% after 2000.

[Table 4 about here]

Consistently, we find that a considerable amount of central city residents lived in high-rise condominium towers. According to the National Population Census 2015, for Chiyoda, Chuo, and Minato (the central three wards of Tokyo), 50%, 64%, and 46% of households, respectively, lived in buildings with 11 or more stories. For the remaining five of the central eight wards, the percentage is slightly lower, ranging between 21% and 47%, still much higher than the average of the entire Tokyo city (16%). The trends in Osaka city are similar.

The discussion above, although seemingly fragmented, can partially verify that, there were increasingly more new high-rise residential buildings in the central cities after the bubble burst, and the proportion of buildings constructed for residential (commercial) use increased (declined). Note that, since the reported figures in Tables 2–4 are obtained from different raw data sources and data availability are limited, they differ in the definition of high-rise buildings (i.e., Table 2 (3) refers to the buildings with six (nine) or more stories; Table 4 denotes the buildings with 60 meters or more in height) and the geographic boundary of the sample area (i.e., Table 2 refers to the cities of Tokyo and Osaka; Tables 3 and 4 refer to the Tokyo Prefecture). However, we are able to ensure that the

[18] Figure 7 shows that construction of "built-to-rent" dwellings is limited after the bubble burst.

reliability of the above discussion will not be essentially undermined, since all the stylized facts are compatible with each other.

4.3 Heterogeneous changes in land prices

We provide supportive evidence from the perspective of heterogeneity of housing and land price changes in this subsection. An argument against our hypotheses would be that the prevalence of high-rise condominium towers reduced the costs of home ownership in central cities after 1995 since their construction was more intensive than that of detached houses in land use, and condominiums would, therefore, cost less. If this were the case, new home buyers are able to incur a relatively lower costs for owning a home.[19] One may expect that gentrification would still happen even if the real estate bubble had not burst.

[Figure 9 about here]

Figure 9 displays the prices of residential land and new condominiums for the Tokyo/Osaka MA in 1991–2017 (data for the earlier years are not available). The observed trends are clearly against the argument above. During 1991–1995, immediately after the bubble burst, the prices for both condominiums and residential land declined significantly compared to their price peaks in 1991. However, we find that the price changes began to diverge after 1995, with condominium prices stabilizing in 1995–2012, and then rebounding, whereas residential land prices declined continuously.[20] Obviously, condominiums, whose construction is more intensive in land use, did not become relatively cheaper than residential land (or, detached houses; the changes in price indices for residential land and detached houses are similar). Instead, they become increasingly expensive relative to residential land. Although this is not directly related to the current study, we propose an explanation for this "abnormal" phenomenon.

By exploiting a transaction level residential land price database (2005–2018), we find that large-sized land (1,000 m^2 or larger) exhibited a significant unit price premium compared to small-sized land (200 m^2 or smaller) in the central locations of the Tokyo/Osaka MA. Since most of the residential land transactions were for small-sized land, the reported residential land price index, which is calculated based on the average unit price for all land transactions, does not reflect the price premium of large-sized land (more strongly correlated with the price of condominiums). Therefore, we find that the trends in the price indices of residential land and condominiums diverged.

One possible explanation for the price premium of large-sized residential land is as follows: Small-sized land can only be used for the construction of detached houses or low-story apartments, whereas large-sized land allows developers to fully exploit the floor-area-ratio, which is set by the government, and the land value by constructing high-rise condominium towers. [Development of high-rise condominium towers needs to take place in a large-sized land parcel, because considerable public areas need to be reserved for public facilities, such as lift.] This result is consistent with Brooks and Lutz (2016), who find that a to-be-assembled land (i.e., two or more parcels of small-sized land to be bundled into parcel of a large-sized land) trades at a 40% premium in Los Angeles.

[19] In addition, a condominium is on average smaller than a detached house (see Figure A3), which makes it relatively affordable. In fact, detached houses are still not affordable for most residents in large cities even after the real estate bubble burst (Seko, 2019).

[20] Note that the price index of new condominiums, as shown in Figure 9, does not consider the potential changes in average dwelling size. Considering the price per m^2, we find that the patterns are largely similar; the unit price of a new (existing) condominium increased by 57.4% (53.8%) during 2005–2017 in the Tokyo MA (Global Property Guide, 2019).

In addition, the condominium price appreciation after 2012 (Figure 9) was partially caused by external economic shocks such as the 2011 Tohoku Earthquake and the (scheduled) 2020 Tokyo Olympic. A more detailed analysis of this issue is provided in an appendix.

4.4 Considering the confounding factors

We are also concerned about the impacts of macroeconomic and demographic trends on our results. First, the share of the aged population (over 65 years old) in Japan increased continuously, from 10% in the early 1980s to 20% in 2005, and did not show an extraordinary growth trend in the early 1990s (see, e.g., Nakamura and Saita (2007)). Second, the share of Japanese GDP and jobs stemming from the tertiary industry became increasingly high during 1970–2000, whereas the secondary and primary industries shrank; there was no extraordinary change in this indicator before and after 1990 (Fujita et al., 2004). In terms of the internal transportation facilities of the Tokyo/Osaka MA, which may affect urban spatial reorganization, we find that the construction of both interregional (high-speed railroads and expressways) and the intraregional (city roads and urban rail transits) facilities had already been completed before 1990. These facts imply that external economic and social factors were not likely to have led to the post-1990 gentrification in the Tokyo/Osaka MA.

Governmental policy to promote the regeneration of central cities also affect our results. The Obuchi Cabinet (1998–2000) and Koizumi Cabinet (2001–2006) treated urban regeneration as a way for large cities to regain their competitiveness, to address the economic recession after the bubble burst (Hirayama, 2017). As a result, policies including the deregulation of urban planning were implemented since 1998. However, the governmental policies favoring central city regeneration and the observed trends of "Recentralization of Central City (*Toshin-Kaiki* in Japanese)" did not materialize until the late 1990s (1998–2000), whereas the "built-to-sell" construction boom in central cities was triggered in the early 1990s (approximately 1993–1995; according to Figure 7, the dashed lines). We can, therefore, conclude that the intense housing construction there was not triggered by the governmental policies, although they might have pushed it forward to some extent. In other words, our analysis is unaffected by the reverse causality problem of the population growth causing the housing boom in the central cities after the bubble burst.

5 Concluding remarks

By observing the population dynamics and the real estate market in Japan's major MAs, we find that the exogenous economic bubble and its burst affected the process of gentrification. For commercial land, the price fluctuations tended to be more intense than for residential land, as a response to external economic shocks. In the period when land prices surged, central locations tended to be dominated by commercial development, squeezing out the residential population. After the bursting of the real estate bubble, the shrinking demand for commercial land, in addition to the improving housing affordability, tended to re-adjust the land use trend in central locations, causing the central area residential population to rise again. Our results verify and supplement the conclusions of 1) Smith (1979), that gentrification might be fundamentally guided by capital, but not people and 2) Ahlfeldt and McMillen (2018), that land prices could be associated with residential-commercial segregation. Moreover, we provide a new perspective for the determinants of gentrification.

Appendix: The price premium of large-sized residential land

We employ a hedonic-type regression model to examine the determinants of vacant residential land price; we pay particular attention on the role of the area of a land. Our data are obtained from a survey-based transaction level land price dataset publicized by the MLIT, released on a quarterly basis (from the third quarter of 2005 through the fourth quarter of 2018).

The dependent variable is set as the natural logarithm of unit land price (million Yen per m^2), and the list of independent variables contains three dummy variables, indicating the transactions for a land with the area of 1,000 m^2 or above, 500–999 m^2, and 200–499 m^2, respectively (land smaller than 200 m^2 is taken as the comparison; more than half of our samples are for the transactions of land smaller than 200 m^2), a dummy variable for road proximity, indicating whether the frontage road of the land parcel is a major road, the natural logarithm of the maximum floor-area-ratio allowed for residential development in this land parcel, the natural logarithm of the time (in minute) to walk to the nearest railway or subway station (summarized statistics are displayed in Table A2). We also control for a body of fixed effects (FEs) to address the time-invariant heterogeneity, including municipality FE, year-quarter FE, and land use zone FE.[21] Estimations are separately conducted using the data of the Tokyo MA and that of the Osaka MA.

Columns 1–4 of Table A3 (panel A) report the baseline results for the entire Tokyo MA, Tokyo city, the central eight wards of Tokyo, and the central three wards of Tokyo, respectively (related results for Osaka are reported in panel B). The large-sized land parcels are significantly cheaper in unit price than the small-sized ones based the data of the entire MA. However, once we condense our data to the central city/wards, we find that there is a significant price premium for the large-sized land. This is reasonable as it is relatively more costly to assemble land parcels in densely populated central locations than in the suburban areas/small cities. Within the central eight wards of Tokyo, the unit price of large-sized residential land parcels (1,000 m^2 or larger) is 75% (= exp(0.557) – 1) higher than that of the small-sized ones (smaller than 200 m^2) on average (column 3 of Table A3; panel A). For those between 500–999 m^2, and between 200–499 m^2, the price premium is estimated at 23% and 20%, respectively. This result is consistent with Brooks and Lutz (2016) that to-be-assembled land parcels tend to trade at a significant premium.

We also estimate the regression model using the data in a shorter time period (2005–2006), as condominium price experienced significant growth after 2006; this was, however, likely to be affected by external factors such as the nationwide economic growth and a positive expectation of the 2020 Tokyo Olympic. Estimates with the data in this restricted time period help us to avoid any potential noisy that these factors may impose on our results. Results shown in columns 5–8 of panel A (Table A3) for the Tokyo MA and columns 4–6 of panel B for the Osaka MA are largely consistent.

[21] Land use zones are areas that are regulated under Japan's City Planning Law and designates the possible usage of land and properties in that area. Land use zones can be generally categorized into residential (seven categories), commercial (two categories) and industrial uses (three categories) (12 zone categories in total). For more details, see Akashi (2007).

We are also concerned about the possibilities that building construction costs for condominiums have experienced rapid growth since 1995, which might cause the diverged price growth between residential land and new condominiums. Figure A5 displays the building construction cost index (CCI) during 1980–2008; due to the data availability, the reported figures are only for the Tokyo city. We find that the CCI for all kinds of residential buildings experienced solid growth between 1985 and 1991, which was partially caused by the nationwide economic bubble in this period. After the burst of bubble economy, the CCI fell for all kinds of residential buildings, with that for condominiums even falling more. This implies that the price premium of new condominiums relative to residential land and detached houses after 1995 was not affected by an extraordinary growth of CCI for condominiums.

The CCI data after 2008 are not available; as a proxy, we present the average wage rates of the constructions industry employees in the period between 2005 and 2017 for the country, and in the period between 2010 and 2017 for the cities of Tokyo and Osaka. We find that the wage rates surged after 2012, which was potentially affected by the 2011 Tohoku Earthquake and the following reconstruction. In addition, the 2020 Tokyo Olympic has triggered considerable infrastructure construction, leading to a shortage of labor supply in this sector and an appreciation of wage rates. These are consistent with the stylized facts that new condominium price experienced extraordinary growth after 2012 (Figure 9).

References

Ahlfeldt, Gabriel M. and Daniel P. McMillen (2018) Tall buildings and land values: Height and construction cost elasticities in Chicago, 1870–2010. *Review of Economics and Statistics* 100, 861–875.

Akashi, Tatsuo (2007) *Urban Land Use Planning System in Japan (2nd Edition)*. Tokyo: Japan International Cooperation Agency and the MLIT.

Baum-Snow, Nathaniel (2007) Did highways cause suburbanization? *Quarterly Journal of Economics* 122: 775–805.

Baum-Snow, Nathaniel and Daniel Hartley (2019) Accounting for central neighborhood change, 1980–2010. Working paper: The University of Toronto and Federal Reserve Bank of Chicago.

Boustan, Leah P. and Robert A. Margo (2013) A silver lining to white flight? White suburbanization and African-American homeownership, 1940–1980. *Journal of Urban Economics* 78: 71–80.

Boustan, Leah P., Robert A. Margo, Matthew M. Miller, James M. Reeves and Justin P. Steil (2019) Does condominium development lead to gentrification. NBER Working Paper 26170.

Boustan, Leah P. and Allison Shertzer (2013) Population trends as a counterweight to central city decline, 1950–2000. *Demography* 50: 125–147.

Brooks, Leah and Byron Lutz (2016) From today's city to tomorrow's city: An empirical investigation of urban land assembly. *American Economic Journal: Economic Policy* 8: 69–105.

Brueckner, Jan K. and Stuart S. Rosenthal (2009) Gentrification and neighborhood housing cycles: Will America's future downtowns be rich? *Review of Economics and Statistics* 91: 725–743.

Brueckner, Jan K., Jacques-Francois Thisse, and Yves Zenou (1999) Why is downtown Paris so rich and Detroit so poor? An amenity based explanation. *European Economic Review* 43: 91–107.

Couture, Victor and Jessie Handbury (2017) Urban revival in America, 2000 to 2010. NBER Working Paper No. 24084.

Cuberes, David, Jennifer Roberts, and Cristina Sechel (2019) Household location in English cities. *Regional Science and Urban Economics* 75: 120–135.

Fujita, Masahisa, Tomoya Mori, J. Vernon Henderson, and Yoshitsugu Kanemoto (2004) Spatial distribution of economic activities in Japan and China. In: Henderson, J. Vernon and Jacques-François Thisse (eds), *Handbook of Regional and Urban Economics* 4: 2911–2977. Amsterdam: The Elsevier.

Fujita, Masahisa and Hideaki Ogawa (1982) Multiple equilibria and structural transition of non-monocentric urban configurations. *Regional Science and Urban Economics* 12: 161–196.

Garcia-López, Miquel-Àngel (2010) Population suburbanization in Barcelona, 1991–2005: Is its spatial structure changing? *Journal of Housing Economics* 19: 119–132.

Glaeser, Edward L. and Joseph Gyourko (2005) Urban decline and durable housing. *Journal of Political Economy* 113: 345–375.

Global Property Guide (2019) Japan's housing market is a picture of stability (March 16, 2019). Retrieved: https://www.globalpropertyguide.com/Asia/Japan/Price-History.

González-Pampillón, Nicolás, Jordi Jofre-Monseny, and Elisabet Viladecans-Marsal (2019) Can urban renewal policies reverse neighborhood ethnic dynamics? *Journal of Economic Geography*, forthcoming. DOI: 10.1093/jeg/lbz011.

Guerrieri, Veronica, Daniel Hartley, and Erik Hurst (2013) Endogenous gentrification and housing price dynamics. *Journal of Public Economics* 100: 45–60.

Hamnett, Chris (2003) Gentrification and the middle-class remaking of inner London, 1961–2001. *Urban Studies* 40: 2401–2426.

Hirayama, Yosuke (2005) Running hot and cold in the urban home-ownership market: The experience of Japan's major cities. *Journal of Housing and the Built Environment* 20: 1–20.

Hirayama, Yosuke (2006) *The End of Tokyo* (*Tokyo No Hateni*) (in Japanese). Tokyo: NTT Shuppan.

Hirayama, Yosuke (2017) Selling the Tokyo sky: Urban regeneration and luxury housing. In Ray, Forrest, Sin-Yee Koh, and Bart Wissink (eds.), *Cities and the Super-Rich: The Contemporary City*. New York: Palgrave Macmillan.

Kanemoto, Yoshitsugu (1997) The housing question in Japan. *Regional Science and Urban Economics* 27: 613–641.

Kobayashi, Masahiro (2016) The housing market and housing policies in Japan, ADBI Working Paper Series No. 558.

Lehrer, Ute and Thorben Wieditz (2009) Condominium development and gentrification: The relationship between policies, building activities and socio-economic development in Toronto. *Canadian Journal of Urban Research* 18: 82–103.

LeRoy, Stephen F. and Jon Sonstelie (1983) The effects of urban spatial structure on travel demand in the United States. *Journal of Urban Economics* 13: 67–89.

Liu, Crocker H., Stuart S. Rosenthal, and William C. Strange (2018) The vertical city: Rent gradients, spatial structure, and agglomeration economies. *Journal of Urban Economics* 106: 101–122.

Lucas, Robert E. and Esteban Rossi-Hansberg (2002) On the internal structure of cities. *Econometrica* 70: 1445–1476.

McKinnish, Terra, Randall Walsh, and T. Kirk White (2010) Who gentrifies low-income neighborhoods? *Journal of Urban Economics* 67: 180–193.

Nakamura, Koji and Yumi Saita (2007) Land prices and fundamentals. The Bank of Japan Working Paper Series No. 07–E–8.

Hideo, Nakazawa (2014) Tokyo's "urban regeneration" as the promoter of spatial differentiation: Growth coalition, opposing movement and demographic change. *The Chuo Law Review* (*Hogaku Shimpo*) 121: 1–31.

Owens III, Raymond, Esteban Rossi-Hansberg, and Pierre-Daniel Sarte (2017) Rethinking Detroit. NBER Working Paper No. 23146.

Rosenthal, Stuart S. (2008) Old homes, externalities, and poor neighborhoods: A model of urban decline and renewal. *Journal of Urban Economics* 63: 816–840.

Rosenthal, Stuart S. and Stephen L. Ross (2015) Change and persistence in the economic status of neighborhoods and cities. In Duranton, Gilles, J. Vernon Henderson, and William C. Strange (Eds.), *Handbook of Regional and Urban Economics* 5: 1047–1120. Amsterdam: The Elsevier.

Seko, Miki (2019) *Housing Markets and Household Behavior in Japan*. Singapore: Springer Nature Singapore Pte Ltd.

Shimizu, Chihiro, Koji Karato, and Yasushi Asami (2010) Estimation of redevelopment probability using panel data: Asset bubble burst and office market in Tokyo. *Journal of Property Investment & Finance* 28: 285–300.

Shimizu, Chihiro and Kiyohiko G. Nishimura (2007) Pricing structure in Tokyo metropolitan land markets and its structural changes: Pre-bubble, bubble, and post-bubble periods. *Journal of Real Estate Finance and Economics* 35: 475–496.

Shimizu, Chihiro, Kiyohiko G. Nishimura, and Tsutomu Watanabe (2009) Residential rents and price rigidity: Micro structure and macro consequences. RIETI Discussion Paper Series 09–E–044.

Smith, Neil (1979) Toward a theory of gentrification: A back to the city movement by capital, not people. *Journal of the American Planning Association* 45: 538–548.

Su, Yichen (2018) The rising value of time and the origin of urban gentrification. Working Paper: Stanford University.

Tabuchi, Takatoshi (2019) Do the rich and poor colocate in large cities? *Journal of Urban Economics* 113: 1–10.

United Nations (2019) *World Urbanization Prospects (The 2018 Revision)*. New York: The United Nations.

Xu, Hangtian and Si Wang (2019) Urban redevelopment and residential location choice: Evidence from a major earthquake in Japan, *Journal of Regional Science*, forthcoming. DOI: 10.1111/jors.12424.

Zhang, Beibei (2017) Housing development in post-war Japan: Historical trajectory, logic of change, and the vacancy crisis. Working Paper: The University of Waterloo.

Tables & Figures

Table 1: Residential population, daytime population, and population growth.

Panel A: Tokyo Prefecture.

	(1)	(2)	(3)	(4)	(5)	(6)
	Residential population growth					
	1990–2015					1980–90
residential/daytime pop. 1990	-0.203***			-0.118*	-0.147*	
	(0.073)			(0.061)	(0.085)	
residential/daytime pop. 1980						0.325***
						(0.035)
distance to central Tokyo		-0.003*		-0.006***	-0.004	
		(0.002)		(0.002)	(0.006)	
ln(pop. density 1990)			-0.046*	-0.135***	-0.196**	
			(0.027)	(0.042)	(0.087)	
N	49	49	49	49	23	49
R-sq	0.325	0.081	0.056	0.524	0.658	0.522

Panel B: Osaka Prefecture.

	(1)	(2)	(3)	(4)	(5)	(6)
	Residential population growth					
	1990–2015					1980–90
residential/daytime pop. 1990	-0.366***			-0.465***	-0.619***	
	(0.059)			(0.059)	(0.098)	
residential/daytime pop. 1980						0.121***
						(0.046)
distance to central Osaka		-0.001		0.000	-0.000	
		(0.002)		(0.003)	(0.009)	
ln(pop. density 1990)			-0.026	-0.087**	0.061	
			(0.021)	(0.038)	(0.064)	
N	56	56	56	56	24	56
R-sq	0.421	0.004	0.018	0.593	0.807	0.107

Notes: See the definitions of the variables in the notes of Table A1. Constant terms are included in the regressions but not reported. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Housing stock in the cities of Tokyo and Osaka.

Year	Housing stock	Detached houses	Condominium (# stories) 1–5	6–10	11–14	≥15	Tenement houses	Others
			The city of Tokyo					
1998	3,468.8	925.1	1,718	714.6			75	36
2003	3,842.4	996.6	1,747.6	565	368.7	73.3	68.1	23.2
2008	4,177.7	1,012.2	1,807.9	672.7	468	134	61.6	21.2
2013	4,601.6	1,060.7	1,880.9	800.8	556	203.2	75.8	24.1
Δ 1998–2013	1,132.8	135.6	162.9	845.4			0.8	-11.9
			The city of Osaka					
1998	1,102.7	233.7	336.9	392.1			132.1	7.9
2003	1,186.9	298.9	314.1	259.6	172.1	49.1	88.4	4.6
2008	1,262.1	303.6	294.3	301.2	201.3	87.5	70.4	3.8
2013	1,343.2	334.1	283.3	331.4	234.4	112.8	43.7	3.4
Δ 1998–2013	240.5	100.4	-53.6	286.5			-88.4	-4.5

Notes: Data are obtained from the Housing and Land Survey (HLS; various years). The reported data are number of dwellings units in thousand. Data containing detailed dwelling structure are only available at the major city level from the HLS. The figures underlined refer to the sum of condominium units in the buildings of “6–10 stories”, “11–14 stories”, and “15 or more stories,” because separate data are not available for 1998.

Table 3: Locations of high-rise buildings in the Tokyo Prefecture.

		# stories			# stories		
		9–12	13–29	≥30	9–12	13–29	≥30
Year	Area	Number of buildings			Proportion		
1980	Central 3	2,095	176		0.40	0.26	
	Central 8	3,476	359		0.66	0.53	
	The city	4,966	666		0.95	0.99	
	The prefecture	5,236	672		1.00	1.00	
1990	Central 3	3,793	287	12	0.36	0.23	0.38
	Central 8	6,464	599	26	0.62	0.49	0.81
	The city	9,925	1,174	32	0.94	0.96	1.00
	The prefecture	10,506	1,223	32	1.00	1.00	1.00
2000	Central 3	4,854	489	34	0.31	0.19	0.39
	Central 8	8,967	1,131	66	0.57	0.45	0.75
	The city	14,578	2,263	86	0.92	0.90	0.98
	The prefecture	15,811	2,517	88	1.00	1.00	1.00
2010	Central 3	6,023	1,090	134	0.28	0.21	0.50
	Central 8	11,587	2,451	207	0.55	0.48	0.78
	The city	19,315	4,640	260	0.91	0.91	0.97
	The prefecture	21,157	5,121	267	1.00	1.00	1.00

Notes: Reported data refer to the number of all the high-rise buildings in the Tokyo Prefecture, including both the residential buildings and buildings for other purposes (e.g., commercial and official buildings). Data sources: Tokyo Prefectural Statistical Yearbook (various years). Related data for Osaka Prefecture and other prefectures in our samples are not available. The figures underlined refer to the sum of the number of buildings of "13–29" and "30 or more" stories, because separate data are not available for 1980.

Table 4: The purposes of super high-rise buildings in the Tokyo Prefecture, by completion time.

Completion time of the building	Residential	Combination of residential & office, commercial	Commercial, office, and others
1980–1984	8.9% (4)	0% (0)	91.1% (41)
1985–1989	18.2% (10)	25.5% (14)	56.3% (31)
1990–1994	14.3% (20)	24.3% (34)	61.4% (86)
1995–1999	16.9% (20)	30.5% (36)	52.5% (62)
2000–2004	35.2% (75)	23.0% (49)	41.7% (89)
2005–2009	39.6% (108)	24.7% (68)	35.5% (97)
2010–2014	27.6% (48)	30.4% (53)	42.0% (73)

Notes: The data shown in the table refer to the building stock for 2015; the figures in parentheses are the number of buildings. Super high-rise buildings refer to the buildings over 60 meters in height. Data sources: Summarized based on the Annual Report of Architectural Statistics 2016, which is released by the Tokyo Metropolitan Urban Development Bureau (Building Planning Division, Urban Architecture Department).

Table A1: Summarized statistics: population growth.

Tokyo Prefecture					
Variable	Obs.	Mean	Std.Dev.	Min.	Max.
persons per km^2 1990	49	10,259	4,990	1,091	20,506
residential/daytime pop. 1980	49	1.023	0.304	0.058	1.433
residential/daytime pop. 1990	49	1.022	0.354	0.038	1.531
pop. growth 1980–1990	49	0.028	0.137	-0.332	0.408
pop. growth 1990–2005	49	0.069	0.081	-0.096	0.373
pop. growth 1990–2015	49	0.152	0.126	-0.029	0.736
distance to central Tokyo (km)	49	18.74	12.86	0	44.85
Osaka Prefecture					
Variable	Obs.	Mean	Std.Dev.	Min.	Max.
persons per km^2 1990	56	8,522	5,337	977	19,552
residential/daytime pop. 1980	56	1.007	0.251	0.131	1.285
residential/daytime pop. 1990	56	1.014	0.272	0.097	1.372
pop. growth 1980–1990	56	0.027	0.092	-0.121	0.325
pop. growth 1990–2005	56	0.022	0.080	-0.137	0.196
pop. growth 1990–2015	56	0.038	0.154	-0.226	0.494
distance to central Osaka (km)	56	13.59	10.08	0	45.50

Notes: Data of residential population are obtained from the Residential Population Survey, which is reported annually by the Local Administration Bureau, Ministry of Internal Affairs and Communications. Daytime population data are obtained from the Tokyo Prefectural Statistical Yearbook and the Osaka Prefectural Statistical Yearbook (various years); data are available for municipality level ward and city only, that for rural towns and villages are not available. Distance between a municipality and central Tokyo/Osaka is calculated based on the distance between its core area and Tokyo/Osaka rail station.

Table A2: Summarized statistics: transaction level residential land prices.

	Tokyo MA					*Osaka MA*				
Variable	Obs.	Mean	Std.Dev.	Min.	Max.	Obs.	Mean	Std.Dev.	Min.	Max.
land price (mil. Yen / m^2)	257,773	0.219	0.321	0.000	23.500	123,360	0.127	0.167	0.000	13.500
land area (1000 m^2–)	257,773	0.057	0.232	0	1	123,360	0.079	0.270	0	1
land area (500–999 m^2)	257,773	0.078	0.268	0	1	123,360	0.097	0.296	0	1
land area (200–499 m^2)	257,773	0.264	0.441	0	1	123,360	0.299	0.458	0	1
time to station (minute)	257,773	20.8	20.5	0	135	123,360	19.8	20.3	0	135
major road (dummy)	257,773	0.062	0.241	0	1	123,360	0.080	0.271	0	1
max. FAR	257,773	175.0	84.9	50	1,300	123,360	195.2	82.7	50	1,000

Notes: Transaction level land price information is publicized by the MLIT on a quarterly basis based on a questionnaire survey. *land area (1000 m^2–)*, *land area (500–999 m^2)*, *land area (200–499 m^2)* are dummy variables denote the lands which are 1,000 m^2 or larger, 500–999 m^2, 200–499 m^2, respectively; the transactions for the residential lands which are smaller than 200 m^2 are taken as the benchmark; *major road* is a dummy variable which is set as one if the frontage road of the land is a prefectural road or a Tokyo Metropolitan road, and set as zero if it is nearby a city/town/village road or a private road; *max. FAR* refers to the maximums floor-area-ratio permitted to the land; *time to station* refers to the time (in minute) to walk to the nearest railway or subway station. For the walking time to the nearest station, the dataset reports the specific time in minute if the walking time is no more than 30 minutes, otherwise, only an interval of time, such as 31–60 minutes, is reported. For the time interval of 31–60, 61–90, 91–120, and 121–150 minutes, we use the median value of each interval, that is, 45, 75, 105, and 135 minutes, respectively, as the approximation.

Table A3: Land area and unit land prices.

Panel A: Tokyo MA.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln(unit residential land price)							
land area (1000 m^2–)	-0.345***	0.185***	0.557***	0.562***	0.010	0.236***	0.659***	0.463*
	(0.006)	(0.016)	(0.050)	(0.125)	(0.025)	(0.041)	(0.123)	(0.255)
land area (500–999 m^2)	-0.383***	-0.019*	0.205***	0.434***	-0.098***	0.061**	0.388***	0.434*
	(0.005)	(0.011)	(0.039)	(0.097)	(0.020)	(0.028)	(0.107)	(0.262)
land area (200–499 m^2)	-0.111***	-0.019***	0.180***	0.387***	0.001	0.049***	0.342***	0.472***
	(0.003)	(0.006)	(0.020)	(0.050)	(0.012)	(0.016)	(0.056)	(0.117)
ln(time to station + 1)	-0.245***	-0.176***	-0.181***	-0.187***	-0.205***	-0.157***	-0.171***	-0.254**
	(0.002)	(0.004)	(0.015)	(0.047)	(0.009)	(0.012)	(0.040)	(0.112)
major road (dummy)	0.119***	0.136***	0.182***	0.383***	0.126***	0.112***	0.143**	0.222
	(0.006)	(0.010)	(0.027)	(0.074)	(0.023)	(0.026)	(0.069)	(0.178)
ln(max. FAR)	0.167***	0.246***	0.527***	0.543***	0.154***	0.216***	0.601***	0.287
	(0.007)	(0.011)	(0.038)	(0.110)	(0.027)	(0.033)	(0.110)	(0.280)
Sample	Tokyo MA	The city of Tokyo	Central 8 wards	Central 3 wards	Tokyo MA	The city of Tokyo	Central 8 wards	Central 3 wards
Time period	Q3, 2005–Q4, 2018				Q3, 2005–Q4, 2006			
N	257,773	45,410	6,748	1,216	13,102	5,936	947	231
R-sq	0.758	0.466	0.464	0.343	0.649	0.468	0.505	0.317

Notes: See the definitions of the variables in the notes of Table A2. Full time period of our quarter data is from the 3rd quarter of 2005 through the 4th quarter of 2018. Our sample refers to the transactions data of empty residential land (no building) only; transaction data for buildings are not included. *year*quarter FE, municipality* FE, and *land use zone* FE are controlled for all the regressions. Constant terms are included in the regressions but not reported. Robust standard errors (clustered at the municipality level) are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A3: Land area and unit land prices (continued).

Panel B: Osaka MA.

	(1)	(2)	(3)	(4)	(5)	(6)
			ln(unit residential land price)			
land area (1000 m^2–)	-0.358***	0.315***	0.800***	0.088**	0.503***	0.710**
	(0.008)	(0.028)	(0.110)	(0.043)	(0.076)	(0.289)
land area (500–999 m^2)	-0.418***	0.112***	0.439***	-0.082**	0.229***	0.429**
	(0.007)	(0.022)	(0.069)	(0.041)	(0.061)	(0.185)
land area (200–499 m^2)	-0.121***	0.096***	0.261***	0.037	0.138***	0.261*
	(0.005)	(0.014)	(0.042)	(0.026)	(0.041)	(0.137)
ln(time to station + 1)	-0.190***	-0.122***	-0.025	-0.187***	-0.105***	-0.211
	(0.003)	(0.011)	(0.043)	(0.018)	(0.032)	(0.130)
major road (dummy)	0.218***	0.129***	0.153**	0.157***	0.238***	0.278
	(0.008)	(0.026)	(0.073)	(0.042)	(0.071)	(0.200)
ln(max. FAR)	0.279***	0.401***	0.814***	0.681***	0.393***	0.566**
	(0.013)	(0.033)	(0.079)	(0.063)	(0.096)	(0.247)
Sample	Osaka MA	The city of Osaka	Central 3 wards	Osaka MA	The city of Osaka	Central 3 wards
Time period		Q3, 2005–Q4, 2018			Q3, 2005–Q4, 2006	
N	123,360	9,542	1,038	3,785	1,242	175
R-sq	0.621	0.408	0.429	0.598	0.446	0.329

Notes: See the definitions of the variables in the notes of Table A2. Full time period of our quarter data is from the 3rd quarter of 2005 through the 4th quarter of 2018. Our sample refers to the transactions data of empty residential land (no building) only; transaction data for buildings are not included. *year*quarter FE, municipality* FE, and *land use zone* FE are controlled for all the regressions. Constant terms are included in the regressions but not reported. Robust standard errors (clustered at the municipality level) are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

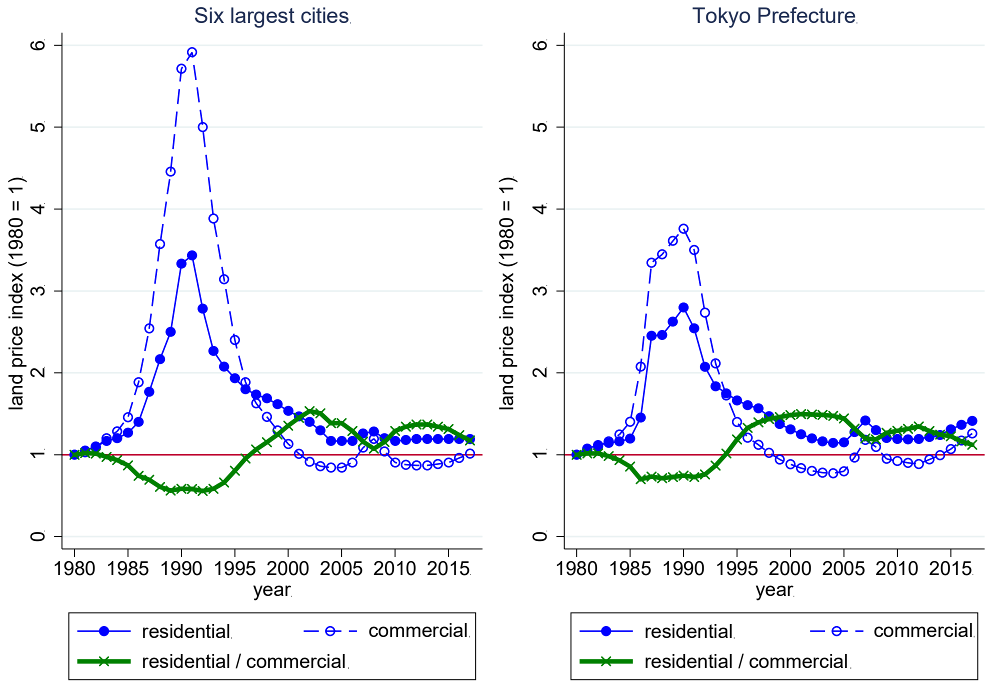


Figure 1: Land price fluctuations in the major urban areas of Japan, 1980–2017.

Notes: Data for the six largest cities are obtained from the CEIC DATA, which report the average land prices in these cities in July of each year (updated to 2002); data of 2003–2017 are obtained from the Japanese Real Estate Statistics 2019, released by the Mitsui Fudosan Co.,Ltd. (Planning and Research Department). The six largest cities of Japan refer to Tokyo (8.10), Yokohama (3.20), Osaka (2.63), Nagoya (2.15), Kobe (1.47), and Kyoto (1.45) (figures in parentheses are residential population sizes of the city in 1990, in million). The data of Tokyo Prefecture are obtained from the Tokyo Prefecture Statistical Yearbook (various years).

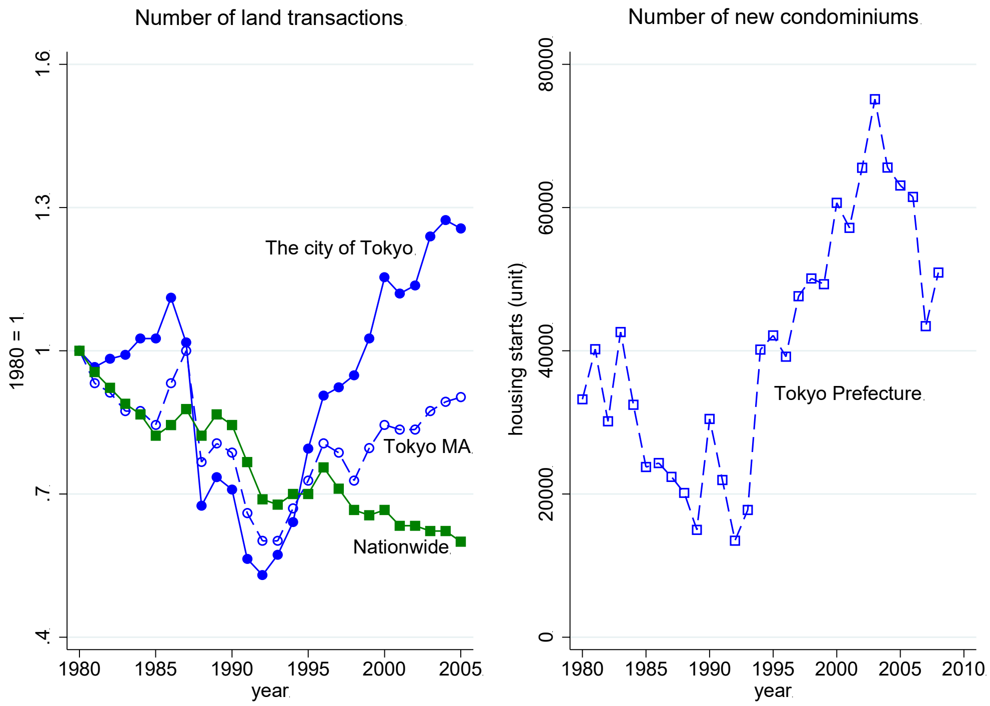


Figure 2: Number of land transactions and new condominiums.

Notes: Data on the number of land transactions are obtained from Nakamura and Saita (2007), which is calculated based on the raw data reported by the Annual Report on Civil Affairs, Litigations and Human Rights, the Ministry of Justice. Data on the number of housing units (1980–2008) are obtained from the Housing Starts Statistics, released by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

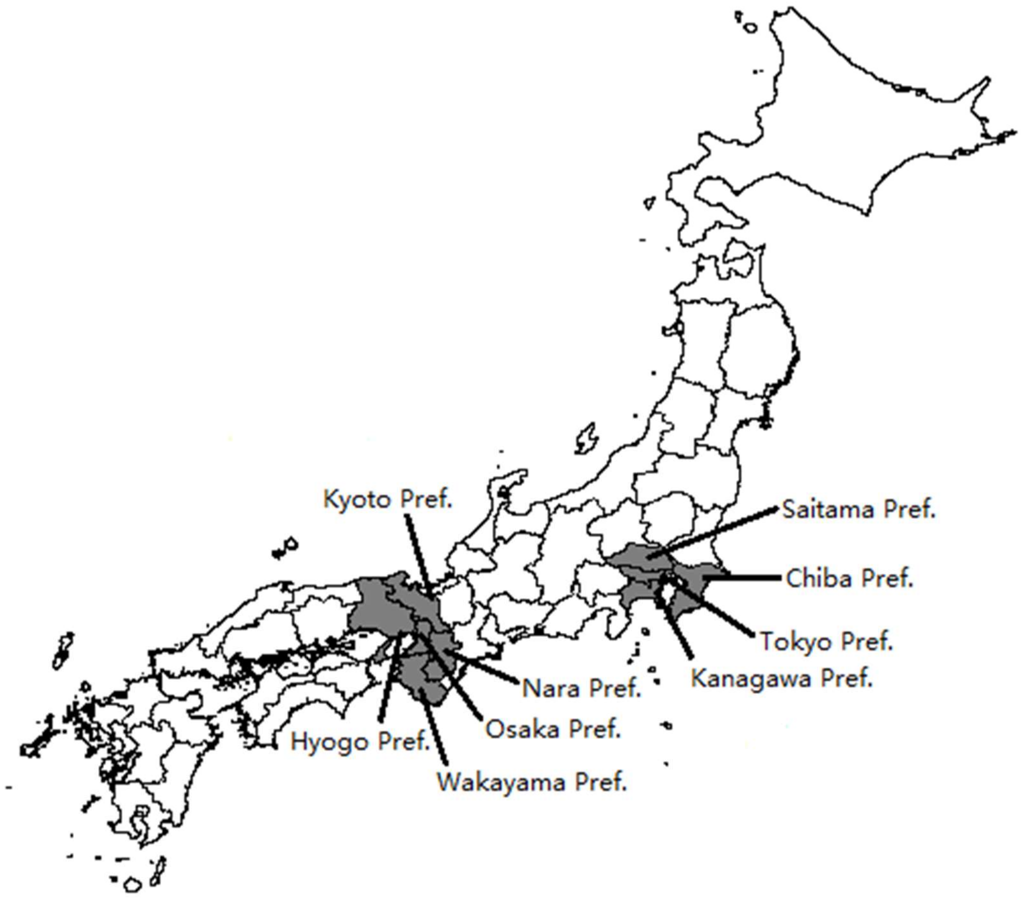
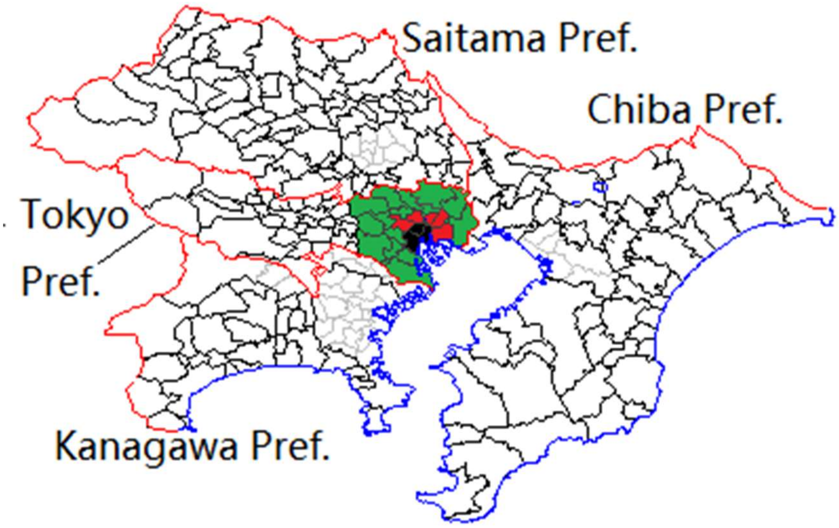
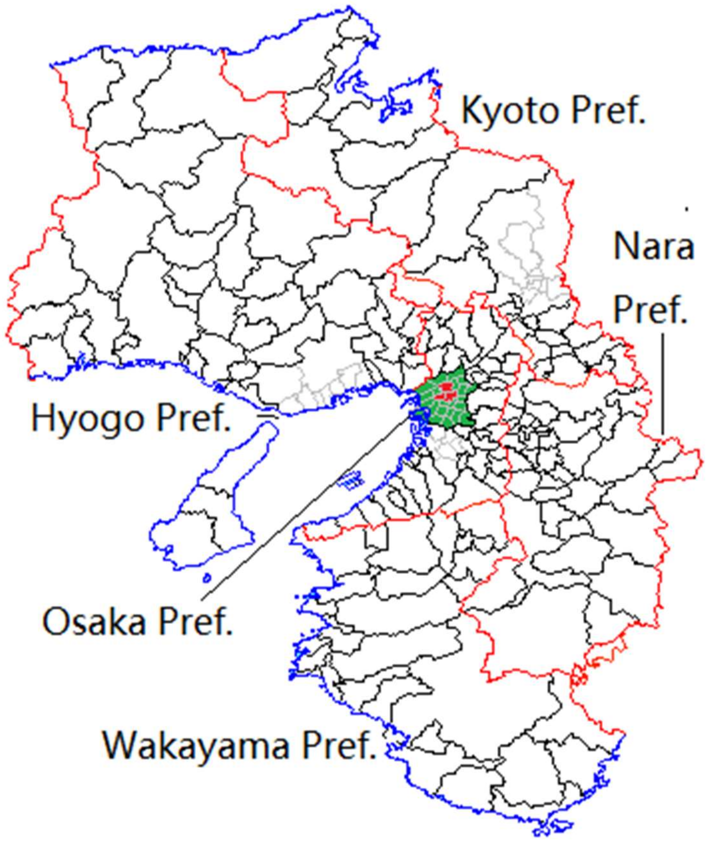


Figure 3: The locations of the Tokyo MA and the Osaka MA.

Notes: The grey area denotes the Tokyo MA, which includes four prefectures (Tokyo, Kanagawa, Chiba, Saitama), and the Osaka MA, which includes five prefectures (Osaka, Kyoto, Hyogo, Wakayama, Nara). This map does not include Okinawa Prefecture.



(a) Tokyo MA



(b) Osaka MA.

Figure 4: The hierarchy of the Tokyo MA and the Osaka MA.

Notes: The map in the top is the zoomed view of the Tokyo MA: the black area is the central three wards of Tokyo city, the area marked red (plus the central three wards) is the central eight wards, the area marked green (plus the central eight wards) is the city of Tokyo (622 km^2). For the zoomed map of the Osaka MA in the bottom, the area marked red is the central three wards of Osaka city, the green area (plus the central three wards) is the city of Osaka (223 km^2). The red lines are prefectural boundaries, the blue lines are coastal lines, and the black (grey) lines are municipality level city (ward) boundaries.

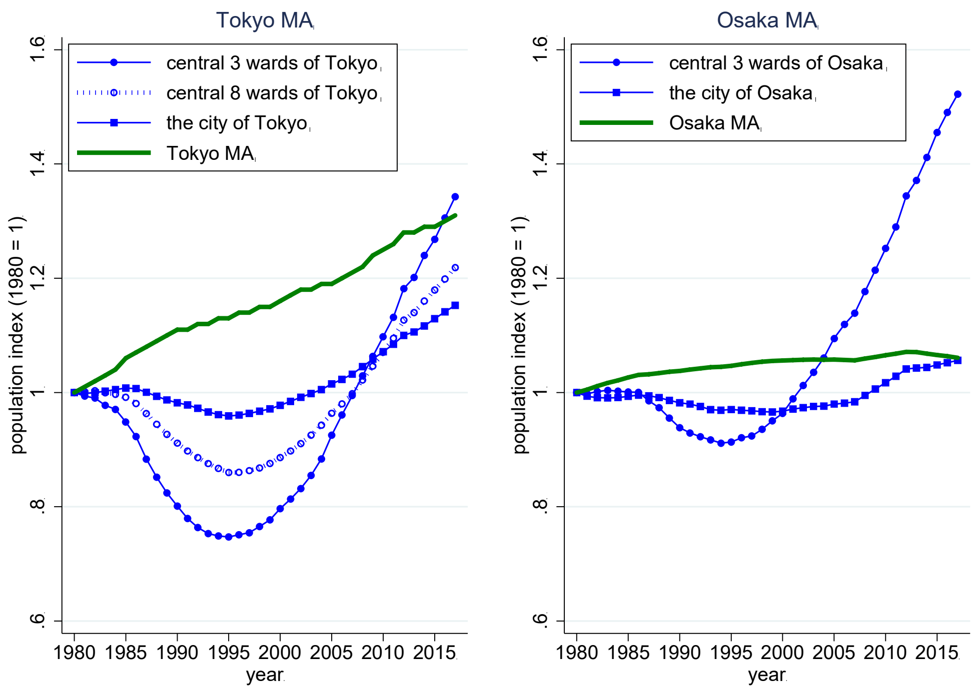


Figure 5: Residential population growth in the Tokyo MA and the Osaka MA.

Notes: Data on residential population are obtained from the Residential Population Survey, which is conducted by the Ministry of Internal Affairs and Communications (the Local Administration Bureau).

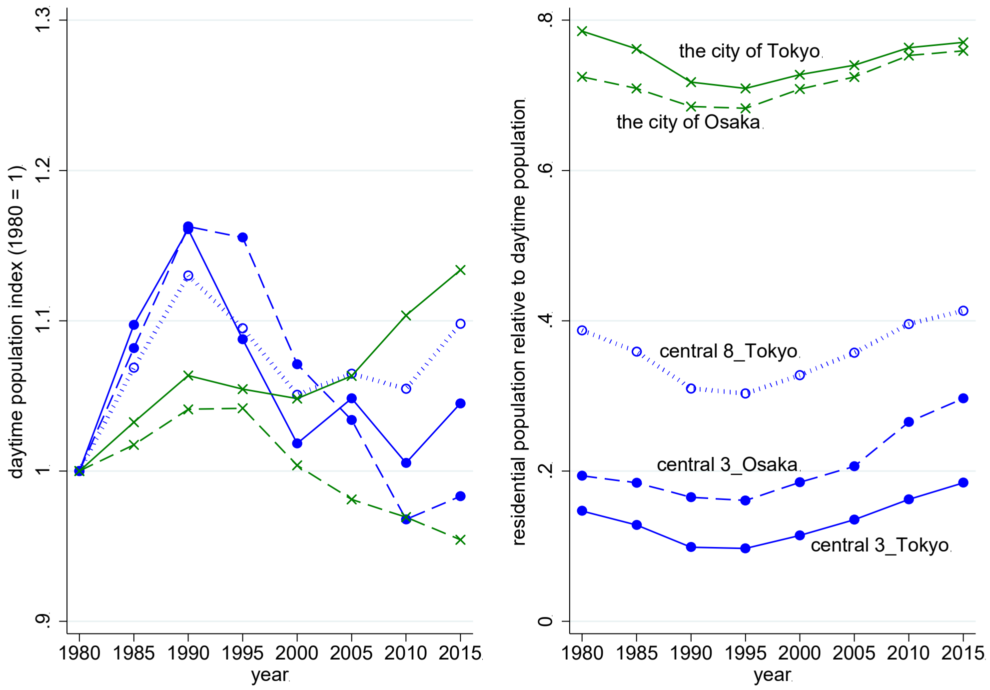
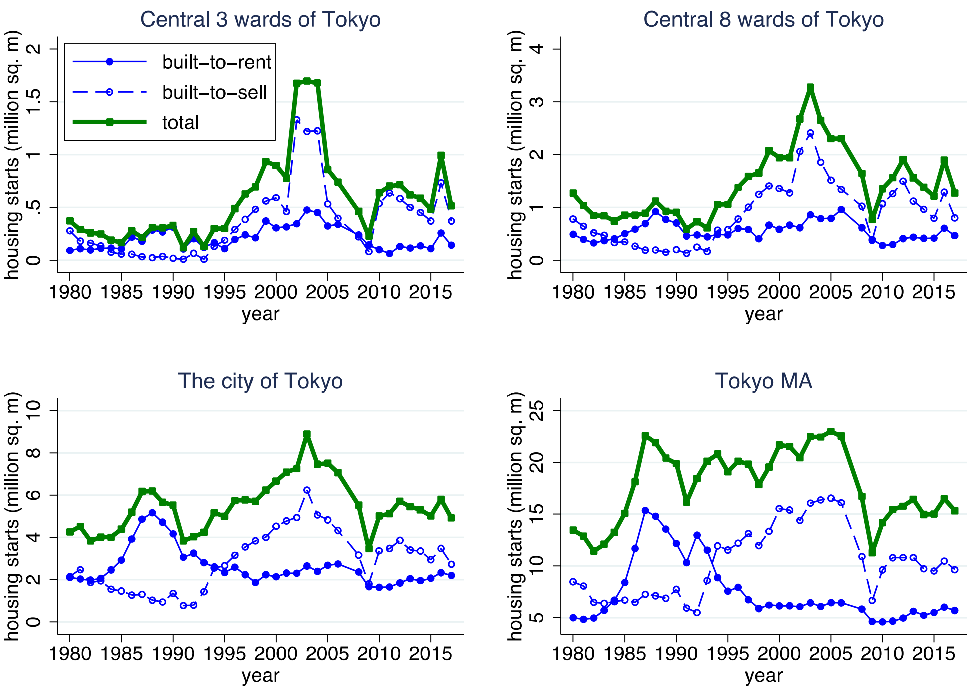
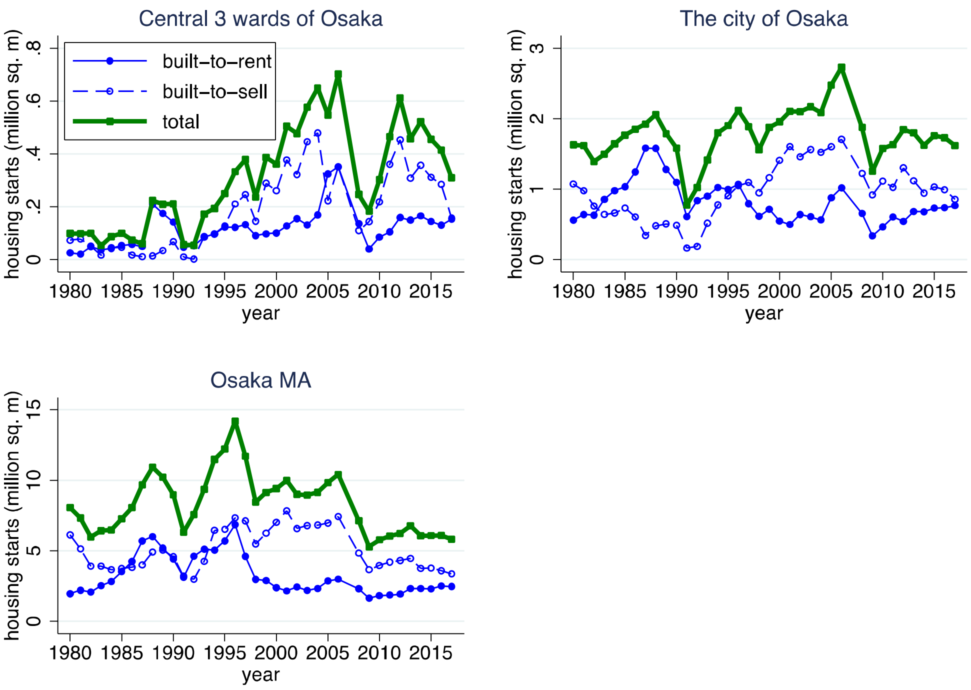


Figure 6: Daytime population growth in the Tokyo MA and the Osaka MA.

Notes: Data are obtained and calculated from the Tokyo Prefectural Statistical Yearbook and Osaka Prefectural Statistical Yearbook (various years).



(a) Tokyo MA.



(b) Osaka MA.

Figure 7: New housing starts, by housing type.

Notes: Data are obtained from the Annual Report of Architectural Statistics, which is released by the MLIT (Department of Information Management, Policy Bureau). Data for 2007 are missing.

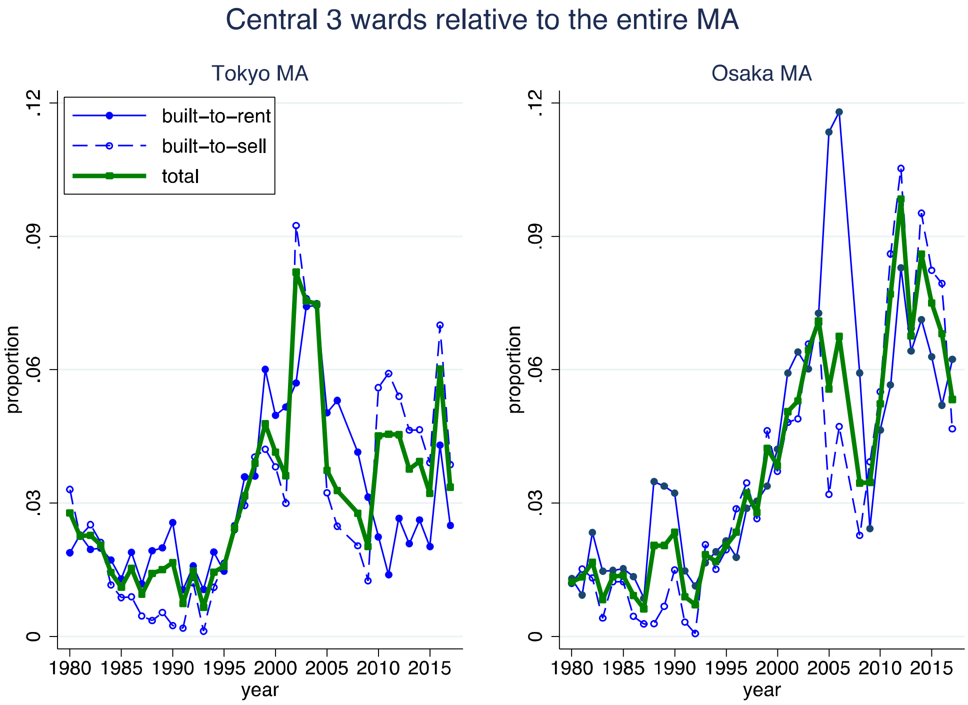


Figure 8: Housing construction intensity in the central locations.

Notes: See the notes of Figure 7 for the information on data sources.

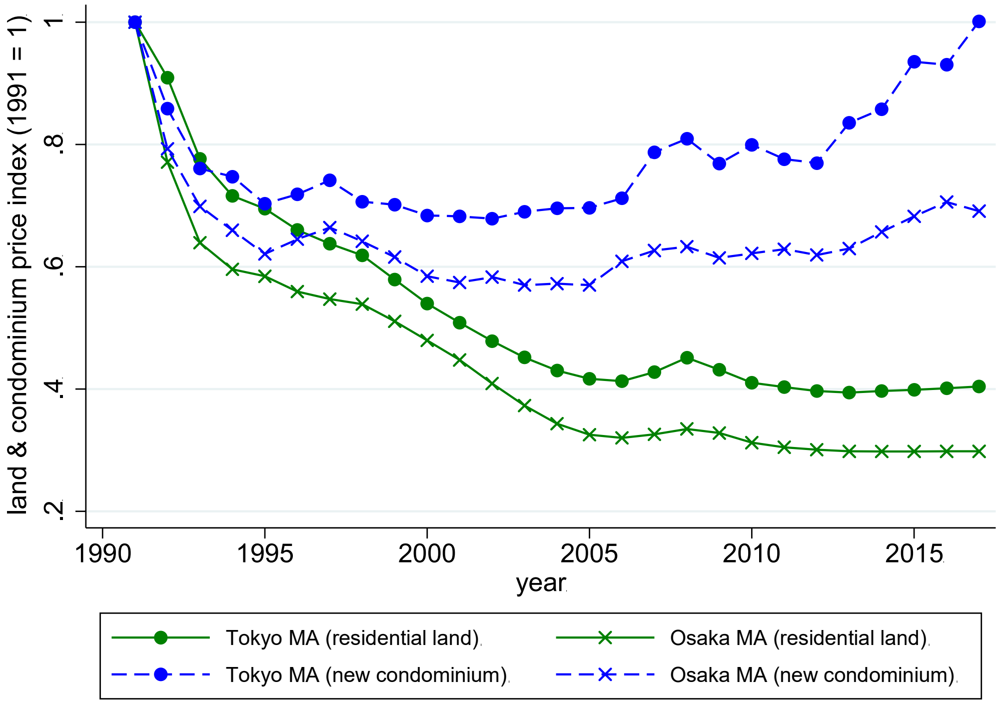


Figure 9: Residential land and condominium prices in the Tokyo MA and the Osaka MA.

Notes: Data are obtained from the Japanese Real Estate Statistics 2019, released by the Mitsui Fudosan Co.,Ltd. (Planning and Research Department). Data of new condominium price index before 1991 are not available.

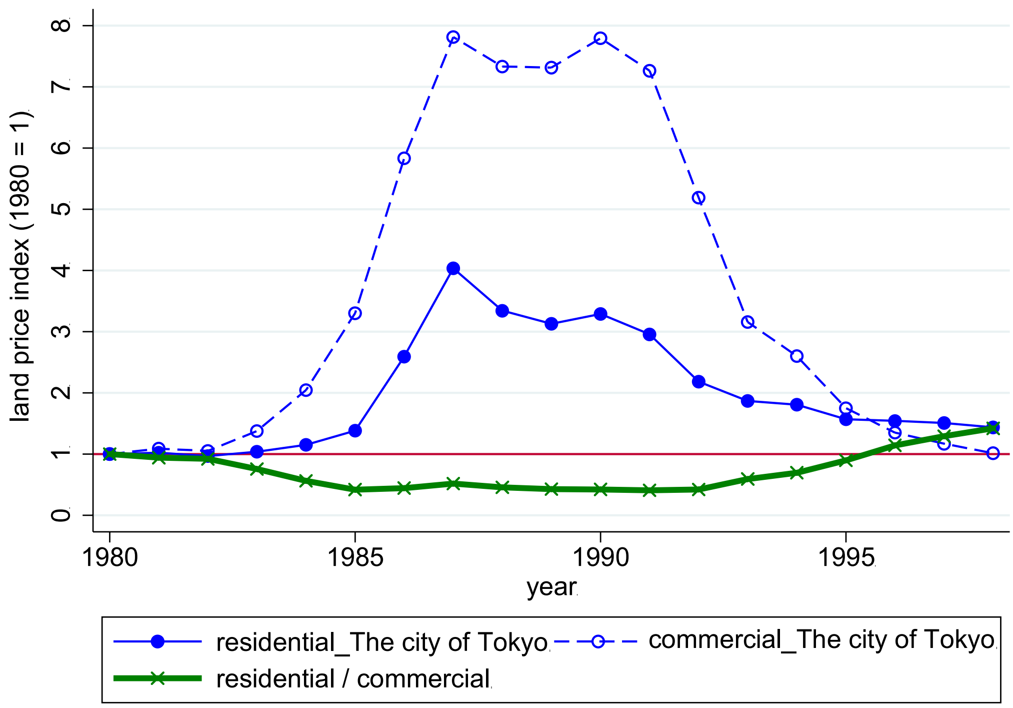


Figure A1: Land prices in the city of Tokyo, 1980–1998.

Notes: Land price data are obtained from Shimizu and Nishimura (2007). For residential land price, it is estimated based on the land transactions in Setagaya ward of Tokyo city; for commercial land price, it is estimated based on the central three wards of Tokyo city (Chiyoda, Chuo, and Minato).

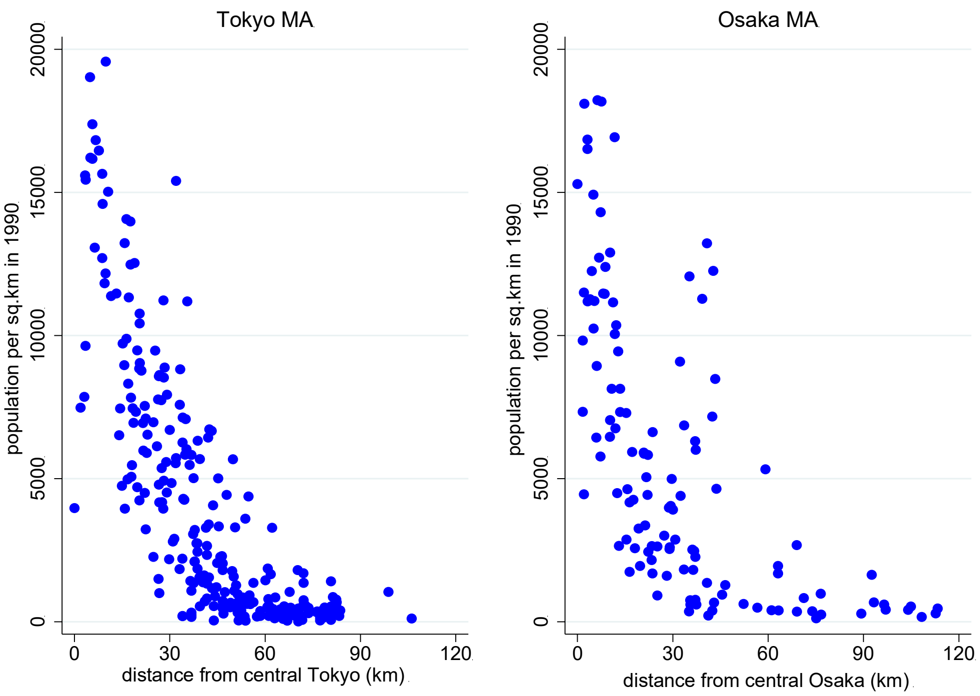


Figure A2: Population density relative to the distance from the central city.

Notes: Data of residential population density are obtained from the Residential Population Survey, which is reported annually by the Local Administration Bureau, Ministry of Internal Affairs and Communications. There are limited municipalities that are located over 120 km from central Tokyo/Osaka, which are less populous and not included in the graph. In 1990, there are 55 municipality wards/cities with a population density greater than 10,000 persons per km^2 in Japan, within which 29 are located in the Tokyo MA (23 in Tokyo Pref., 5 in Kanagawa Pref., and 1 in Saitama Pref.) and 26 are located in the Osaka MA (22 in Osaka Pref., 3 in Kyoto Pref., and 1 in Hyogo Pref.).

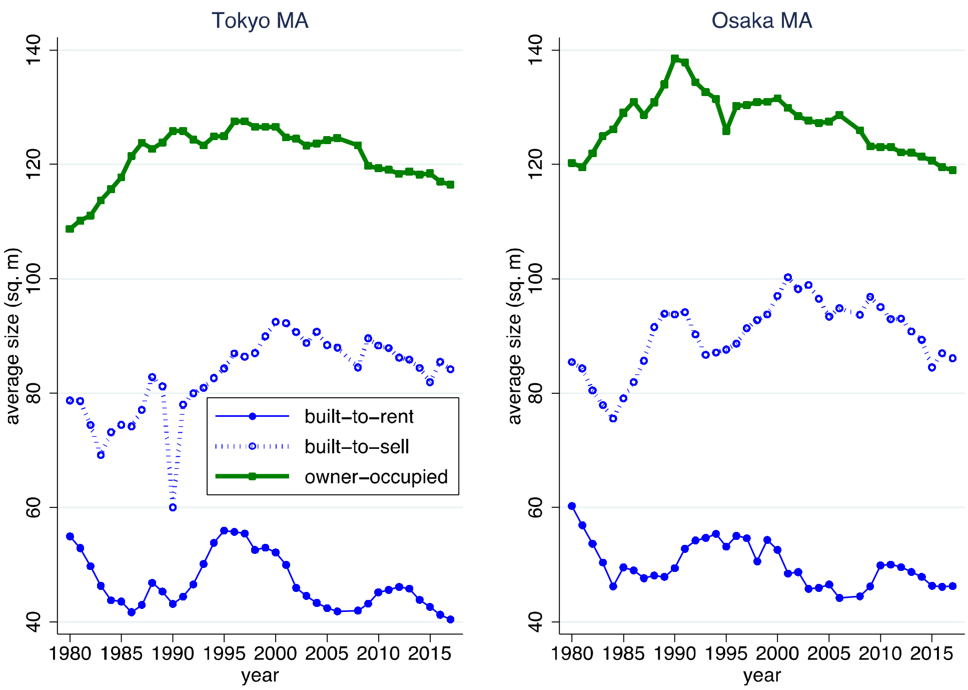


Figure A3: Average dwelling size, by housing type.

Notes: Data are calculated on the basis of the raw data from the Annual Report of Architectural Statistics, released by the MLIT (Department of Information Management, Policy Bureau). Data of 2007 are missing. For the Tokyo MA, the average size of "built-to-sell" dwellings exhibits a significant drop in 1990, however, we are not able to uncover this abnormal pattern by checking the raw dataset.

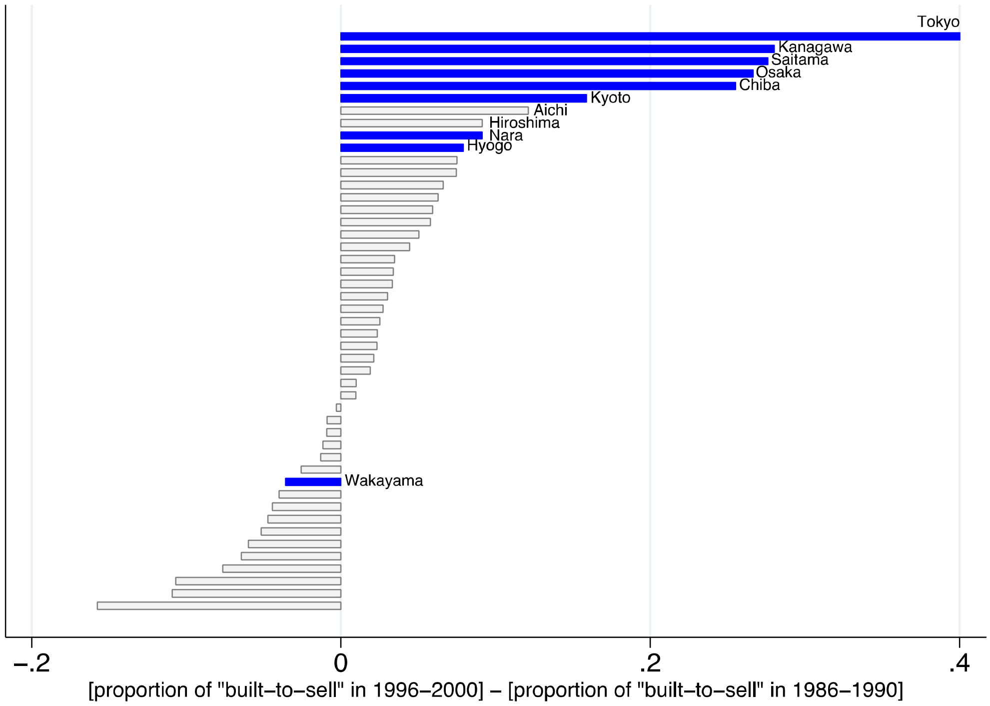


Figure A4: Changes in the types of housing starts before and after the bubble burst.

Notes: The graph shows the differences between *the proportion of "built-to-sell" in newly built housing (here we refer to the sum of the "built-to-sell" and the "built-to-rent" dwellings) in 1996–2000* and *the average value of this indicator in 1986–1990* in the 47 prefectures of Japan, sorted by the size of this difference. The nine prefectures marked blue form the Tokyo/Osaka MA.

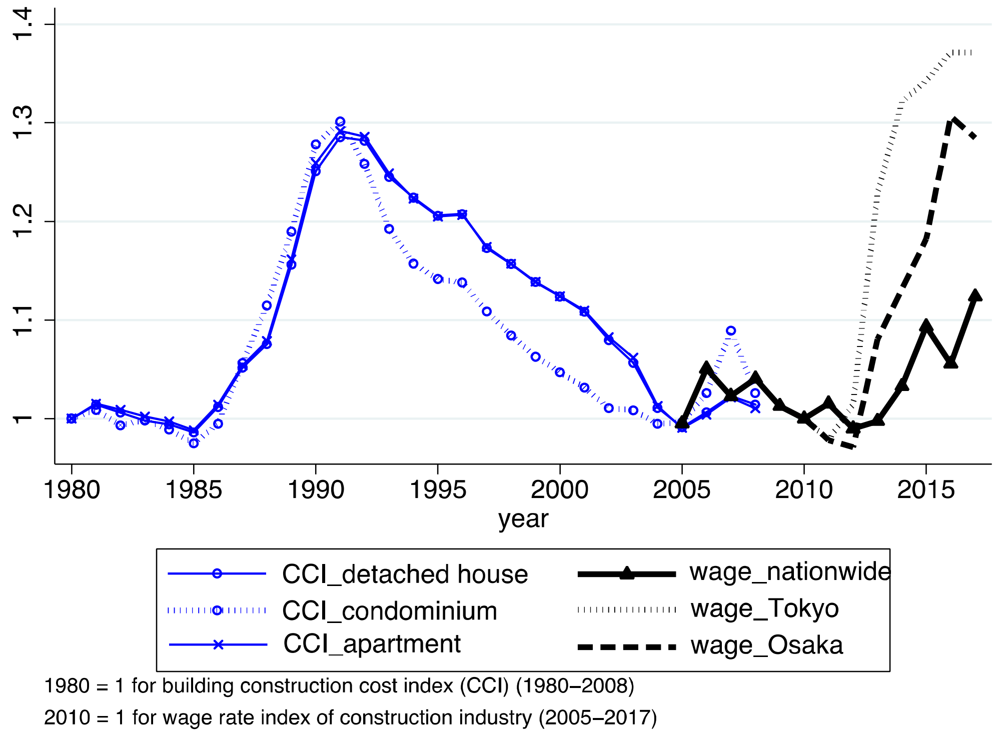


Figure A5: Indices of building construction costs and wage rate of construction industry.

Notes: Building construction cost index (CCI) in the period of 1980–2008 is obtained from the Historical Statistics of Japan (this dataset reports only the related data for the city of Tokyo). For condominium, the reported CCI refers only to the steel-frame and reinforced concrete structure buildings; for detached house and apartment, it refers only to the wooden structure buildings. Average wage rate of the construction industry employees is obtained from the publicly reported data of the Research Institute on Building Cost; related data are available in 2005–2017 for nationwide, and in 2010–2017 for the cities of Tokyo and Osaka.